WILDFIRE EFFECTS EVALUATION PROJECT

APPENDIX C: WATERSHEDS

UMPQUA NATIONAL FOREST

April 2003

Appendix C: Watershed

	A	B	C	D	E	F	G	H
1	Subwatershed Name	Total Acres in Subwatershed	Percent Burned in 2002 Fires	Acres of Class I, II, and III Riparian Reserves	Percent in Class I, II, and III Riparian Reserves	Miles of Road	Road Density (mi./mi.2)	% Early Seral in Subwatershed
2	Apple Creek Facial	11831	19%	1955.30	17%	54.57	2.95	31%
3	Panther Creek	12165	70%	2492.07	20%	78.32	4.12	58%
4	Calf Creek	12537	63%	1987.58	16%	52.74	2.69	33%
5	Quartz Creek	11826	76%	1756.68	15%	60.48	3.27	41%
6	Black Rock Creek	20646	14%	2636.69	13%	125.11	3.88	39%
7	Boulder Creek/MSU	23329	99%	3270.34	14%	75.01	2.06	47%
8	Dumont Creek	19818	36%	2548.34	13%	114.87	3.71	37%
9	Castle Rock Fork	27154	33%	3820.54	14%	61.96	1.46	19%
10	Skillet/Emerson Facial	11362	57%	1553.53	14%	79.32	4.47	33%
11	Ash/Zinc Facial	14197	35%	2236.49	16%	85.40	3.85	33%
12	Buckeye Creek	16049	15%	2305.92	14%	113.53	4.53	35%
13	Jackson Headwater	18186	50%	2223.11	12%	58.30	2.05	22%
14	Upper Jackson Facial	18830	14%	2864.21	15%	113.09	3.84	33%

	A	K	L	M	O	P	Q	S	T
1	Subwatershed Name	% Early Seral and Roaded	Acres of Early Seral in Class I, II, III Riparian Reserves	Miles of Road in Class I, II, III Riparian Reserves	% of Class I, II, III Riparian Reserves in Early Seral and Roaded	% LSR/ Wilderness	% Matrix	% Private	% Administratively Withdrawn/ RNA
2	Apple Creek Facial	34%	291	13.16	19%	84%	15%	0%	0%
3	Panther Creek	62%	1213	11.72	52%	1%	99%	0%	0%
4	Calf Creek	36%	280	4.63	15%	100%	0%	0%	0%
5	Quartz Creek	44%	476	2.69	28%	100%	0%	0%	0%
6	Black Rock Creek	43%	575	8.5	24%	100%	0%	0%	0%
7	Boulder Creek/MSU	49%	976	12.27	32%	100%	0%	0%	0%
8	Dumont Creek	40%	688	8.79	29%	99%	0%	0%	0%
9	Castle Rock Fork	21%	213	7.34	7%	100%	0%	0%	0%
10	Skillet/Emerson Facial	38%	324	13.03	26%	50%	49%	1%	0%
11	Ash/Zinc Facial	36%	570	14.39	29%	6%	93%	1%	0%
12	Buckeye Creek	39%	663	14.24	32%	5%	91%	0%	5%
13	Jackson Headwater	24%	321	7.83	17%	88%	12%	0%	0%
14	Upper Jackson Facial	37%	668	16.47	27%	34%	63%	0%	1%

Table 1C: Sub-watershed Sensitivity Index (Post 2002 Fires)

Hydrologic Risk

Rain-on-Snow Susceptibility and Hydrologic Risk Map are available online: ftp://ftp2/fs.fed.us/incoming/r6/ump/weep. The mapping procedures for these maps are described in the following narrative:

Peak Flow Influence on Stream Bank Erosion

Stream bank stability, that is the bank erosive processes, is highly variable over time and location (MacDonald, 1991). Stream bank erosion can be a result of mass wasting or surface erosion processes. These processes can occur as chronic (annual winter storms) or episodic (infrequent channel forming events) sediment inputs. However, the relative amounts are difficult to quantify. No data exist for stream bank erosion rates in the Little River Watershed. In the absence of bank erosion rates, an alternative approach to describe this potential input component of the sediment budget was necessary.

Stream banks in alluvial systems tend toward a dynamic equilibrium with streamflow and sediment load (MacDonald, 1991). Alluvial channels also tend to be more adjustable by lateral movement than V-shaped channels with less alluvium. The geomorphic terrain, bank material, and vegetation (type and density) are also important factors influencing bank erosion. Extreme events such as floods, wildfire, and landslides likely affect bank erosion for the short-term in comparison to climatic change that is a long-term influence (MacDonald, 1991).

Channel-forming floods impact bank erosion and landslides. The large channel-forming runoff events in the North and South Umpqua sub-basins occur during the winter as rain-on-snow and rain-on-rain events. The influence of upslope management activities on such peak flows has been the subject of much discussion and research in the Pacific Northwest. A common conclusion of the research has been that statistically significant peak flow increases are associated with canopy removal and roads in smaller drainages (Jones and Grant, 1996; Thomas and Megahan, 1998; Jones, 2000). The loss of canopy and road ditch connection to streams can influence the size of peak flows and the runoff efficiency (Wemple et al, 1996). The loss of canopy increases snow accumulation and melt rate. The hydrologic recovery of the canopy may require 40 years (Harr and Coffin, 1992) while the affect of roads are long lasting unless it is disconnected from the stream network or decommissioned. Hydrologic recovery also includes a canopy closure of 70 percent with an average tree diameter of 8 inches to provide snow interception and buffer warm wind movement (Christner, 1982). In the absence of a recovered canopy, soil water input is greater from increased snow accumulation and melt rate. Higher amounts of water input for the same climatic event shifts the frequency of occurrence of water input to a shorter recurrence interval which can influence higher streamflows and channel erosion (Harr, 1981; Harr and Coffin, 1992). Other anthropogenic influences are soil compaction and channel roughness, while soil depth, drainage pattern and climatic response are independent of management activities.

The potential influence of canopy removal and watershed characteristics on peak flow response was selected as an alternative to qualitatively describe potential bank erosion. That is, the potential to erode stream banks was qualitatively described by the hydrologic condition of the upslope vegetation and the susceptibility to influence rain-on-snow runoff events.

A qualitative peak flow approach was adapted from the Augusta Creek Study (Cissel et al, 1998) to address potential bank erosion. The potential susceptibility to rain-on-snow peak flows was evaluated across the watershed by assessing the potential to accumulate and melt snow and store ground water. Snow accumulation is a function of elevation and was grouped in elevation zones. Snowmelt was grouped by aspect with the highest melt rates for the south- and west-facing slopes. Soil depth was used for ground water storage and interpreted from soil inventory data. The elevation ranges, aspect, and soil depth, were merged into a single GIS map to identify areas of High/Moderate/Low susceptibility to rain-on-snow peak flows throughout the Augusta Creek study area.

The elevation zones for snow accumulation in the fire areas were based on 12 snow course sites that characterize the greater North Umpqua Sub-basin. The Natural Resource Conservation Service operates these sites. Two sites are located just outside the sub-basin but provide a higher elevation perspective on the boundary of the sub-basin. The 12 sites are displayed in Table 2C:

SNOW COURSE	**ELEVATION**	**ELEVATION**	**January**	**February**
	ft	m	1961-90	1961-90
RED BUTTE #6	2000	610	0.2	0
RED BUTTE #5	2500	762	0.9	0.3
RED BUTTE #4	3000	914	1	1.4
RED BUTTE #3	3500	1067	1.6	2.4
TRAP CREEK	3800	1158	4.7	7.9
RED BUTTE #2	4000	1219	2.8	4.9
NORTH UMPQUA	4220	1286	5.5	9.4
RED BUTTE #1	4560	1390	4.8	7.6
HOLLAND MDWS PILLOW	4900	1493	12.4	18.6
DIAMOND LAKE	5320	1621	7.5	12.2
DIAMOND LAKE PILLOW	5320	1621	8.1	11.7
SUMMIT LAKE PILLOW	5600	1707	17	23.1

Table 2C:. North Umpqua Sub-basin snow courses used to determine snow accumulation zones.
(USDA-NRCS/WCC web site http://www.wcc.nrcs.usda.gov/snow/)

These locations include three SNOTEL sites (i.e.; pillow sites) where telemetric instrumentation is operated.

The historic snow water equivalent (SWE) data were used to determine three snow accumulation zones. SWE is the accumulative amount of water in the snow pack. These snow zones appear to stratify at less than 3600 feet (<1100 meters), 3600 - 4600 feet (1100-1400 meters), and greater than 4600 feet (>1400 meters). The elevations were analyzed in meters for comparison to the Augusta work then converted to feet. Figures 1C and 2C display the final results for the long-term January and February measurements:

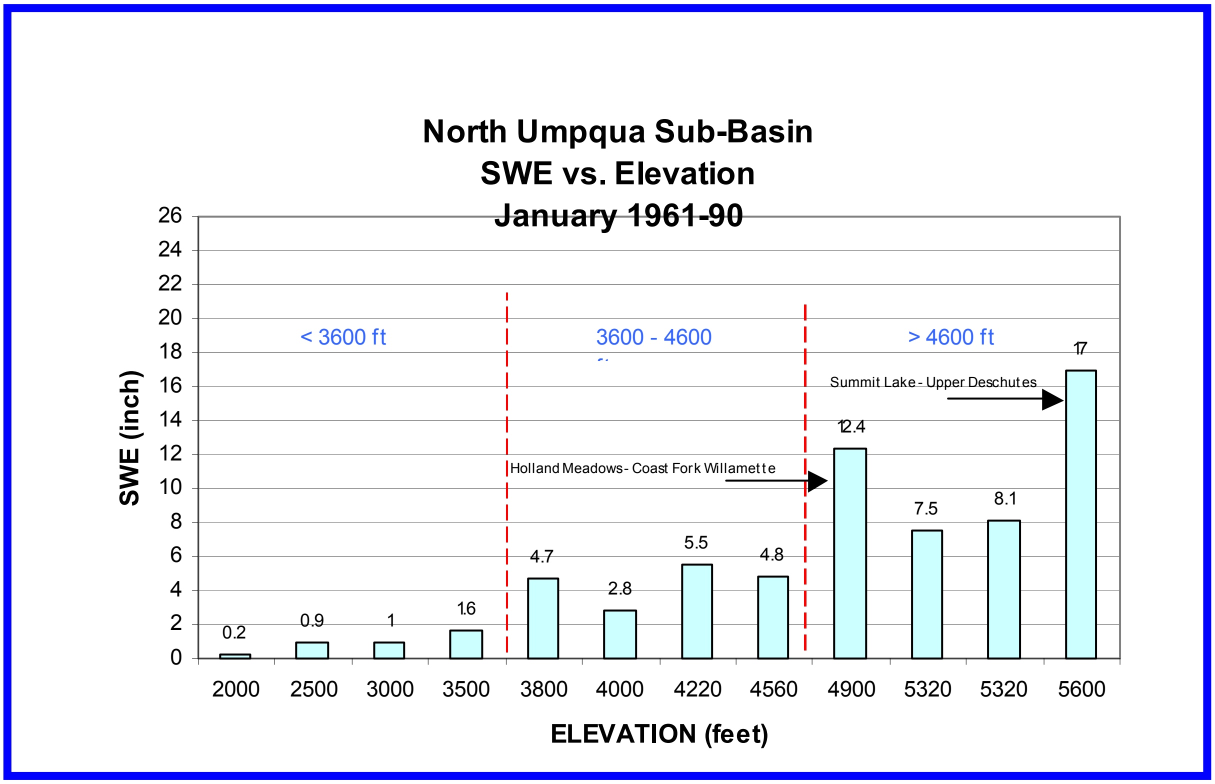

Figure 1C: Snow Accumulation for January 1961- 90 at 12 Sites in the North Umpqua Sub-basin

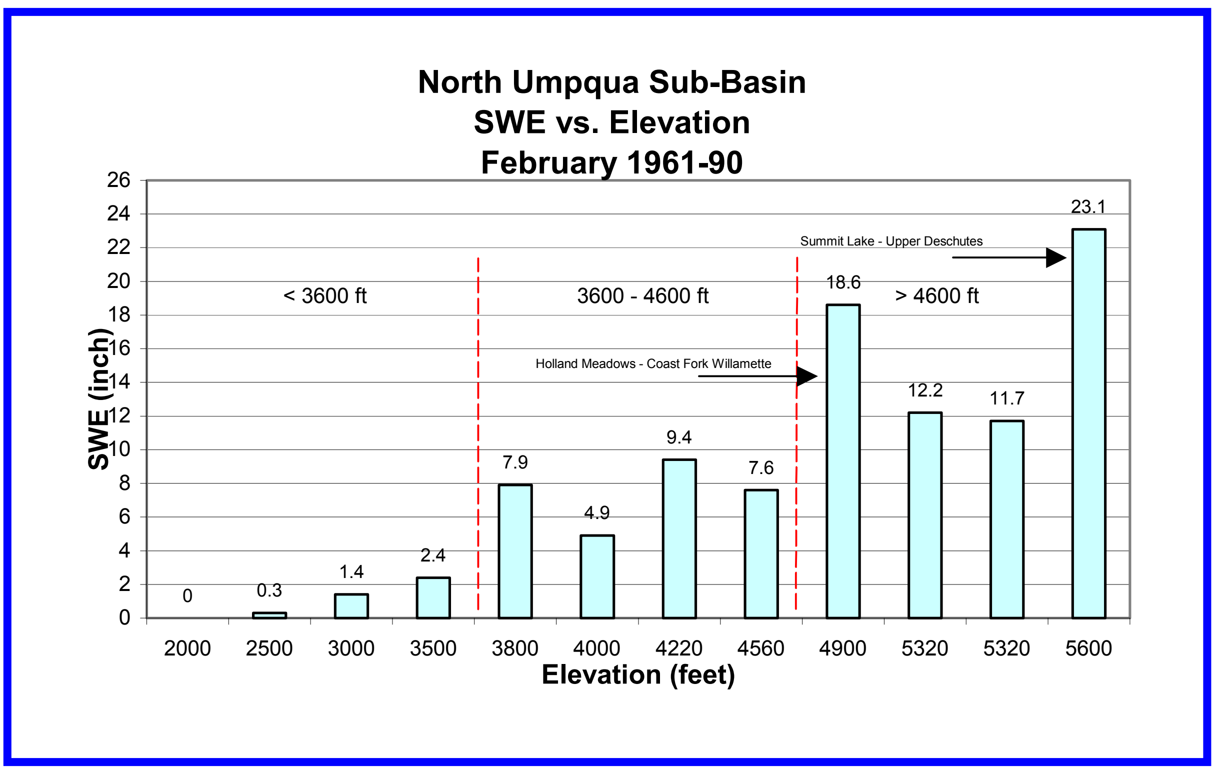

Figure 2C: Snow accumulation for February 1961- 90 at 12 Sites in the North Umpqua sub-basin.

The aspect influence on snowmelt identified in the Augusta Creek Study was assumed to be the same for the subwatersheds containing the 2002 fires. The south- and west-facing slopes were identified with the highest potential melt rates.

Groundwater storage was defined by soil depth. The BLM and Umpqua National Forest Soil Scientists identified a soil depth of 40 inches as the break between shallow and deep soil. Soil depth for this exercise was interpreted from landscape analysis data

These three variables were merged in the GIS environment with the following criteria for rain-on-snow susceptibility (Table 3C):

ELEVATION RANGE (feet)	**ASPECT**	**SOIL DEPTH**	**RAIN-ON-SNOW SUSCEPTIBILITY**
<3600	W, SW, S	Shallow	High
<3600	SE, NW	Shallow	Moderate
<3600	N, NE, E	Shallow	Low
<3600	W, SW, S	Deep	Moderate
<3600	SE, NW	Deep	Low
<3600	N, NE, E	Deep	Low
3600-4600	W, SW, S	Shallow	High
3600-4600	SE, NW	Shallow	High
3600-4600	N, NE, E	Shallow	Moderate
3600-4600	W, SW, S	Deep	High
3600-4600	SE, NW	Deep	Moderate
3600-4600	N, NE, E	Deep	Low
>4600	W, SW, S	Shallow	Moderate
>4600	SE, NW	Shallow	Moderate
>4600	N, NE, E	Shallow	Low
>4600	W, SW, S	Deep	Moderate
>4600	SE, NW	Deep	Low
>4600	N, NE, E	Deep	Low

Table 3C. Potential susceptibility to rain-on-snow peak flows within the fire-affected sub-watersheds.

A GIS map was produced which displayed the High/Moderate/Low susceptibility to rain-on-snow peak flows across the sub-watersheds (Wildfire Effects Evaluation Project, Figure 27). The areas of higher risk to augment rain-on-snow runoff were mid-elevation with southerly aspect and shallow soil depth.

The higher risk locations in the fire-affected sub-watersheds, as defined by the Augusta Creek Study, were then overlaid with forest stands that are not hydrologically recovered to produce a Hydrologic Risk Map (Wildfire Effects Evaluation Project, Figure 28). Managed stands in the early seral stage (less than 40 years old) and fire mortality areas (burned plantations and stand-replaced patches) were considered “hydrologically unrecovered” (Wildfire Effects Evaluation Project, Figure 25). The Hydrologic Risk Map identified those areas that have both a higher risk to naturally augment rain-on-snow runoff because of elevation, aspect, and soil depth while likely hydrologically unrecovered.

Bank erosion maybe of greatest concern where areas of moderate or high risk for rain-on-snow susceptibility overlap with hydrologically unrecovered areas. Table 3 shows the percent of each of the fire-affected subwatersheds fire that are most susceptible to stream bank erosion (highlighted). This qualitative view of potential bank erosion does not factor bank vegetation and channel condition.

Subwatershed Name	% of Subwatershed in <70% Canopy Cover/Low Susceptibility	% of Subwatershed in <70% Canopy Cover/Mod Susceptibility	% of Subwatershed in <70% Canopy Cover/High Susceptibility
Apple Creek Facial	15%	10%	6%
Panther Creek	37%	15%	6%
Calf Creek	20%	8%	5%
Quartz Creek	20%	12%	8%
Black Rock Creek	17%	13%	9%
Boulder Creek/MSU	19%	16%	12%
Dumont Creek	22%	9%	6%
Castle Rock Fork	10%	7%	3%
Skillet/Emerson Facial	18%	14%	2%
Ash/Zinc Facial	20%	10%	2%
Buckeye Creek	17%	11%	7%
Jackson Headwater	11%	7%	4%
Upper Jackson Facial	17%	13%	3%

Table 4C. Rain-on-snow susceptibility

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Slope Stability Hazard Map (SHALSTAB)

A map of stand-replacement fire mortality was combined with a shallow-rapid landslide hazard to assess post-fire landslide hazard. The SHALSTAB model for the Apple Fire vicinity is displayed in Figure 3C. A 2002 fire area SHALSTAB model is available online: ftp://ftp2/fs.fed.us/incoming/r6/ump/weep.

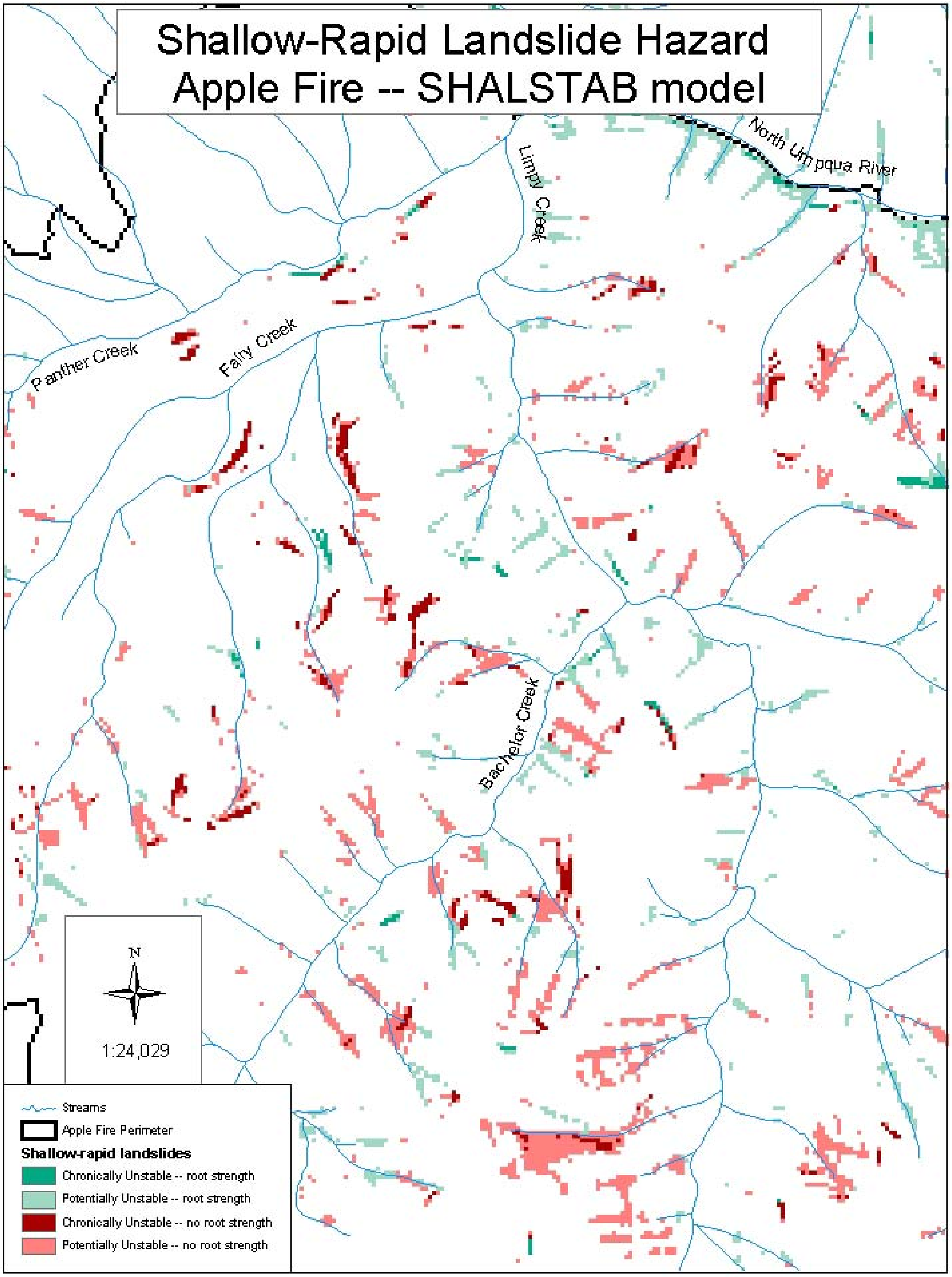

Figure 3C: Apple Fire SHALSTAB Model

Landslide Assessment using SHALSTAB

Description and Application

SHALSTAB is a mechanistic, grid-based digital terrain model that can be utilized as a management tool for landscape level slope stability analysis. It is designed to delineate preferred sites of slope failure, specifically for shallow-rapid landslides in a steep, well-dissected landscape. An advanced version of SHALSTAB termed SHALSTABco is used to assess shallow-rapid landslide potential within the Upper South Umpqua watershed. This recent version allows the analyst to calibrate soil property values in the model. SHALSTAB is a product of a collaborative effort between the Department of Geology and Geophysics (renamed Earth and Planetary Science), University of California (Berkeley) and Stillwater Sciences, Inc., Berkeley, California. SHALSTAB was developed by Bill Dietrich, a researcher in the field of fluvial geomorphology who currently teaches at the UC Berkeley (**Montgomery and Dietrich, 1994**).

SHALSTAB theory is based on the observation that shallow rapid landslides tend to occur primarily within topographic swales, sites of concave slope form located between the ridge crest and the initiation point of first-order stream channels. During high intensity rainfall events shallow subsurface flow converges within topographic hollows that lead to increased soil saturation. As soil pore pressures increase soil shear strength is reduced. SHALSTAB links a steady-state, shallow, subsurface flow model with a cohesionless infinite plane slope stability model to estimate the relative potential for shallow landsliding across a dissected landscape (**Dietrich and Montgomery, 1998**).

Steep topographic hollows are perceived to gradually fill with coarse-textured sediment transported under the influence of gravity from adjacent convex slopes by a variety of surface erosion mechanisms described above. Since the sediment residing in topographic hollows is gravity transported, these landforms are also referred to as colluvium-filled swales (**Figure 3**). The recurrence interval for slope failure within an individual colluvium-filled swale is thought to be on the order of a few centuries possibly ranging up to several thousand years (**Swanson and others, 1987**). A debris avalanche that initiates from a colluvial swale can attain sufficient fluidity and momentum to propagate into a much larger and more devastating channel scouring debris flow. Debris flows typically involve only a portion of the colluvium stored in a swale and debris flows can be released from an individual swale over many years (**Montgomery and others, 1991**).

Factors and Parameters

The SHALSTABco digital terrain model integrates slope gradient and slope convexity with soil parameters that include internal friction angle, saturated bulk density, and cohesion to predict potential sites of slope instability (**Stillwater Ecosystem, Watershed & Riverine Sciences, 2000**). Slope gradient and slope convexity are obtained from the digital elevation model based on 10-meter resolution topographic data. Soil property values are variables that are input into the SHALSTABco digital terrain model. According to **Dietrich and Montgomery (1998**) relative slope stability for the SHALSTAB digital terrain model is predicted by the following equation:

$$q/T = K\,(1-\tan\theta/\tan\phi)\; b/a\,\sin\theta$$

q = steady-state effective precipitation minus evaporation and deep drainage, T = soil transmissivity (ground's subsurface ability to convey water downslope), K = soil bulk density ratio of γ_s/γ_w , γ_s = soil wet bulk density, γ_w = water bulk density, θ = hillslope gradient, ϕ = internal friction angle of soil mass, a = upslope drainage area, b = localized width of hill slope across the drainage flow path.

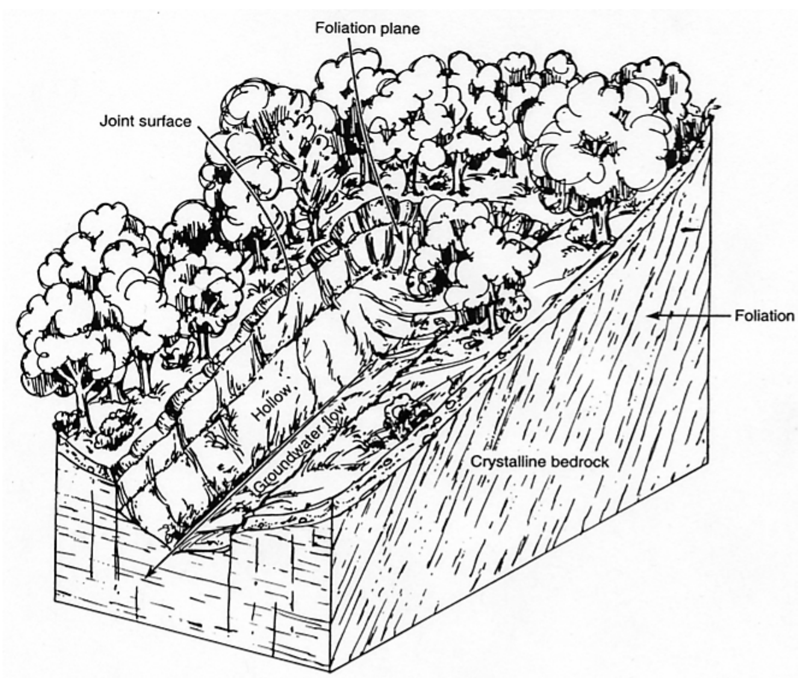

Figure 4C. Colluvial hollow following slope failure (debris avalanche)

This equation states that for a given soil transmissivity (T) value and soil internal friction angle (ϕ), the more convergent the local slope (the smaller the value of b/a) and the steeper the slope gradient (θ), the smaller the amount of steady-state precipitation (q) is required to cause instability. The hydrology ratio (q/T) is a relative measure of slope stability, with low (negative) values associated with sites requiring the least amount of precipitation to induce instability. Each grid cell (pixel) within the digital terrain model is assigned a specific hydrology ratio (q/T) that defines its relative degree of slope stability. The SHALSTAB digital terrain model derives seven relative risk categories for slope stability ranging from "chronically unstable" to "stable" (**Table 5C**). Logarithmic (q/T) values more negative than -3.1 that are inclusive of "chronically unstable" and "high potential instability" categories have a strong tendency for slope failure. (**Stillwater Ecosystem, Watershed & Riverine Sciences, 2000**).

SHALSTABco Risk Categories	Logarithmic q/T values
Chronically unstable	< -9.9
High potential instability	-9.9 to –3.1
Moderate-high potential instability	-3.1 to -2.8
Moderate potential instability	-2.8 to -2.5
Low-moderate potential instability	-2.5 to –2.2
Low potential instability	-2.2 to 9.8
Stable	> 9.8

Table 5C. SHALSTABco risk categories listing threshold logarithmic q/T values

Limitations and Constraints

As with earlier versions of the SHALSTAB digital terrain model, the SHALSTABco version contains simplifying assumptions regarding the landscape such as uniform soil depth of 1.0 meter regardless of slope gradient, and uniform rainfall intensity on all slope aspects and elevations. Perhaps the most significant weakness of the SHALSTAB is that its accuracy is largely driven by the resolution of input topographic data – the digital terrain model that it is linked to. The slope stability analysis for the Upper South Umpqua watershed is based on relatively refined 10-meter pixels, a derivative of the ground topography portrayed on USGS topographic sheets. The contour spacing portrayed on USGS topographic maps (and their derivative 10-meter pixel digital versions) do not provide sufficient detail or accuracy to effectively delineate most of the smaller topographic hollows and swales that are present in a steep well-dissected landscape. The model does effectively delineate broad headwalls that contain several swales or larger well-defined swales.

For any given storm event or limited observational period it is expected that only a fraction of those sites with q/T values equal to or below the threshold value of q/T <-3.1 will experience a landslide. Those sites that have appropriately low q/T values indicative of inherent slope failure, but do not exhibit evidence (field signatures) of recent failure, have different local conditions or parameters than those input into the SHALSTAB model, such as a higher friction angle, greater cohesion, reduced transmissivity, or a different subsurface flow field than predicted (**Stillwater Ecosystem, Watershed & Riverine Sciences, 2000**).

The SHALSTABco digital terrain model is strictly intended for predicting the spatial distribution of relatively small shallow-rapid type landslides, and not for predicting large, deep-seated mass movement features such as bedrock failures, rotational slumps and earth flows. Landscapes for which the SHALSTABco digital terrain model is not expected to perform well include terrain dominated by deep-seated landslides or areas of massive rock outcroppings (cliffs and bluffs), or areas with deep groundwater flow and locally emergent springs and seeps. The SHALSTABco digital terrain model requires a well-defined soil-bedrock boundary (interface) and not a soft, clay-rich saprolitic zone that can develop on some of the deeply weathered volcanic lithologies that underlie gently sloping and weakly dissected terrain **(Stillwater Ecosystem, Watershed & Riverine Sciences, 2000)**.

Calibration

Soil properties in the SHALSTABco digital terrain model were calibrated so that the combined acreage of "chronically unstable" and "high potential instability" classifications (q/T values more negative than -3.1) roughly approximates observable rates of landslide frequency within the Upper South Umpqua watershed. The chronological landslide inventory completed for the 87,135 acre Upper South Umpqua (fifth-field) watershed was utilized to derive landslide frequency rates for both natural occurring and timber-related landslides. Road-related landslides were not included in this analysis. A total of approximately 162 acres of natural-occurring and timber-related rapid-shallow landslides were detected within the Upper South Umpqua watershed by aerial photo interpretation. This chronological landslide inventory represents about a 50-year period spanning from about 1950 to 1998. The 162 acres of observable rapid-shallow landslides equates to about 0.2 percent of the Upper South Umpqua watershed.

For purposes of this slope stability analysis the recurrence interval for rapid-shallow landslides within individual topographic hollows is assumed to be on the order of 400 years. A 400-year recurrence interval for shallow-rapid landslides reflects about an eight-fold increase in comparison to the 50-year chronological landslide inventory for the Upper South Umpqua watershed. Extrapolating the 162 acres of natural occurring and timber related landslides to the theoretical 400-year recurrence interval for slope failure in the SHALSTABco digital terrain model equates to about 1300 acres or roughly 1.6% of the Upper South Umpqua watershed total acreage. Based on this approach, the percent of "chronically unstable" and "high potential instability" sites within the Upper South Umpqua watershed that are anticipated to experience slope failure is approximate about 2.0 percent of the watershed area over a 400-year timeframe.

As the chronological landslide inventory is based on aerial photo interpretation that lacks field verification it is recognized that considerable uncertainty exists regarding the acreage of observed landslide features within the Upper South Umpqua watershed. Hence the theoretical value of 2 percent used to calibrate the SHALSTABco digital terrain model for the existing (current) condition is just an approximation. Further uncertainty arises since the SHALSTABco digital terrain model is based on several simplifying assumptions discussed previously.

Soil Property Values

Tree roots are thought to stabilize slopes by providing a laterally reinforcing layer that acts as a membrane to hold the underlying soil in place. Tree roots also serve to anchor an unstable soil mantle to fractured rock substrate. In the later case the roots penetrate downward through a potential failure plane that typically occurs at the interface between the soil mantle and underlying bedrock. Tree roots can be thought of as supplemental cohesion within the soil mass (**Denning, 1994**).

After regenerative timber harvest or severe wildfire, tree roots begin to decay and the tensile (elastic) strength provided by root fibers begins to decrease. The period of minimum tree root reinforcement based on field studies and research has been shown to extend from a period of roughly 3-5 years following harvest or wildfire to 10-20 years afterwards, depending upon the degree of vegetative re-growth. In areas that are severely burned following wildfire, minimum root strength may occur within the first 3-year period. After about 10 to 20 years post-harvest, tree root reinforcement will increase to its prior uncut level if sufficient vegetative re-growth has occurred. During the period of minimum strength, tree root reinforcement could conceptually be 20 to 40 percent of its undisturbed value (**Denning, 1994**).

Soil property values input into the SHALSTABco digital terrain model for the Upper South Umpqua watershed are designed to simulate the existing condition – the post fire landscape. Soil values are displayed in **Table 6C**. A soil friction angle (ϕ) of 35^0 is representative of granular, loosely compacted, gravel to sandy gravel typical of coarse-textured sediment that accumulates within a colluvial swale, especially along the interface with underlying bedrock. According to **Burroughs and others** (**1976**) a normal saturated bulk density (γ_s) for such granular material is about 1700 kg/m^3 (kilograms per cubic meter) or 106 lbs/ft^3. A soil cohesion (C) value of 2000 n/m^2 (Newton's per square meter) or 41.8 lbs/ft^2 is representative of a soil mass that has inherent capillary tension (shear resistance), but lacks tensile strength associated with tree root reinforcement. A soil cohesion value of 2000 n/m^2 is representative of a soil mass some 3 to 5 years following regenerative timber harvest or wildfire resulting in tree mortality. A soil cohesion value of 3,300 n/m^3 (68.8 lbs/ft^3) incorporates capillary tension present in the soil mass plus the additive tensile strength provided by tree root reinforcement (**Denning, 1994**).

Existing Condition	**Soil Parameters input into SHALSTAB**		
	Friction angle (ϕ)	**Bulk Unit Density** (γ_s)	**Cohesion** (C)
In areas not affected by intense fire	35	1700 kg/m^3 (106 lbs/ft^3)	3,300 n/m^2 (68.8 lbs./ft^2)
In areas of tree mortality (loss of tree root reinforcement)	35	1700 kg/m^3 (106 lbs/ft^3)	2,000 n/m^2 (41.8 lbs./ft^2)

Table 6C. Soil properties entered into SHALSTABco digital terrain model

Table 7C portrays areas within the Upper South Umpqua watershed that have a high susceptibility for the occurrence of rapid-moving, shallow-seated landslide occurrence – inclusive of "chronically unstable" and "high potential instability" categories (q/T values more negative than –3). These two categories have been combined into one entity. The remaining five categories have been grouped into another entity. Pixel clumps shown in red depict areas within tree mortality (where tree root reinforcement is lacking), whereas areas in green reflect areas not affected by intense fire (where tree root reinforcement exists).

"Chronically unstable" is defined as slopes that are steeper than the angle of repose for unconsolidated (loose) materials – that being 35 degrees or 70 percent. Slopes in the "chronically unstable" category are therefore steeper than that which saturated soils can be stable and therefore likely reflects areas with considerable bedrock exposure, including rock ledges.

Based on the above soil values entered into the SHALSTABco digital terrain model, a total of _____ acres (x.x percent) of the 87,135-acre Upper South Umpqua watershed are anticipated to have a strong tendency for slope failure within an assumed 400-year (geomorphic) timeframe. The acreage of anticipated slope failure consists of "chronically unstable" and "high potential instability" risk classifications

Slope Stability Risk Classification	Logarithmic q/T values	Pre Harvest Existing Condition	
		Acres	Percent
Chronically unstable	> -9.9		
High potential instability	-9.9 to –3.1		
Moderate-high potential instability	-3.1 to -2.8		
Moderate potential instability	-2.8 to -2.5		
Low-moderate potential instability	-2.5 to –2.2		
Low potential instability	-2.2 to 9.8		
Stable	>9.8		
Totals		87,135	100.0

Table 7C. Slope stability risk categories (by acres and percent) under the existing condition

The SHALSTABco digital terrain model is strictly intended for use as a landscape-level planning tool to delineate potential areas in steep, well dissected terrain that are susceptible to the occurrence of rapid-moving, shallow-rapid landslides. SHALSTABco categories that are at highest risk for slope instability include “chronically unstable” and “high potential instability”.

Water Quality Limited Streams

In Oregon, the Department of Environmental Quality (DEQ) is required by the federal Clean Water Act to maintain a list of steam segments that do not meet water quality standards. This list is called the 303(d) List because of the section of the Clean Water Act that makes the requirement. Section 303(d) of the Clean Water Act requires each state to develop water quality standards that protect *beneficial uses* such as drinking water, cold water fisheries, industrial water supply, recreation, and agricultural uses. The state must monitor water quality and review available data to determine if the standards are being met and water is protected for what it will be used for. The list serves as a guide for developing and implementing watershed recovery plans to protect beneficial uses. There are several streams within the fire-affected subwatersheds that are listed as water quality limited on the 303(d) List (Table 8C).

Table 8C. Water quality limited waterbodies within fire-affected subwatersheds.

North Umpqua Sub-basin		
Subwatershed	**Water Quality Limited Waterbody**	**Listing Parameter(s)**
Apple Creek Facial	Steamboat Creek	Temperature
Panther Creek	Panther Creek	Temperature, Habitat Modification
Panther Creek	Fairy Creek	Habitat Modification
Calf Creek	Calf Creek	Temperature
South Umpqua Sub-Basin		
Subwatershed	**Water Quality Limited Waterbody**	**Listing Parameter(s)**
Castle Rock Fork	Castle Rock Fork	Temperature
Black Rock Fork	Black Rock Fork	Temperature, Habitat Modification
Quartz Creek	Quartz Creek	Temperature
Skillet/Emerson	South Umpqua River	pH, Sediment, Temperature
Buckeye Creek	Buckeye Creek	Temperature, Habitat Modification
Boulder Creek	Boulder Creek	Temperature, Habitat Modification
Boulder Creek	Slick Creek	Temperature
Dumont Creek	Dumont Creek	Temperature, Habitat Modification, Biological Criteria
Ash/Zinc Facial	South Umpqua River	Sediment, Flow, pH, Temperature
Upper Jackson Facial	Jackson Creek	Sediment, Biological Criteria, pH, Temperature, Habitat Modification
Jackson Headwater	Jackson Creek	Sediment, Biological Criteria, pH, Temperature, Habitat Modification
Jackson Headwater	Falcon Creek	Temperature

The effect of the 2002 fires on these listed streams will generally be to retard recovery of the listing parameters. For example, temperature increases are expected with decreased stream canopy cover due to removal of vegetation by the fires. Increased sedimentation and turbidity are also expected as a result of the fires. One parameter that may improve due to the fires might be Habitat Modification. Fire killed trees delivered to streams may improve the structural component of the channels.

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